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## **Validating the Western Neuro Sensory Stimulation Profile for patients with severe traumatic brain injury who are slow-to-recover**

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# Validating the Western Neuro Sensory Stimulation Profile for patients with severe traumatic brain injury who are slow-to-recover

## Abstract

**Background/aim** The Western Neuro Sensory Stimulation Profile (WNSSP) is designed to measure disorders of consciousness in people with severe traumatic brain injury who are slow-to-recover. This study explores internal consistency reliability and concurrent validity of the WNSSP with function and two other consciousness measures. **Method** Retrospective chart audit of all severe traumatic brain injury patients admitted to a specialist neurological rehabilitation centre from January 2001 to December 2006 in a vegetative or minimally conscious state. Medical record of demographical, clinical and Glasgow Coma Scale (GCS) data were recorded. To be included in the study, patients needed admission and discharge WNSSP results; plus Functional Independence Measure™ (FIM™) and Rancho Los Amigos Scale (RLAS) scores. **Results** Of 37 potential participants, 33 had required WNSSP results (mean age 28 years; 27 male participants). Internal consistency reliability was very high ( $\alpha = 0.933$ ). Concurrent validity in relation to function was significant but weak at admission for FIM™ Total-scale but not subscales ( $r_s = -0.146$ ,  $P = 0.0424$ ). At discharge, there was a modest relationship with FIM™ Motor-subscale ( $r_s = 0.374$ ;  $P = 0.045$ ), and FIM™ Cognition-subscale ( $r_s = 0.412$ ;  $P = 0.026$ ) scores, but not the FIM™ Total-scale. Concurrent validity in relation to the RLAS was strong at admission ( $r_s = 0.693$ ,  $P = 0.01$ ) and discharge ( $r_s = 0.788$ ,  $P = 0.01$ ). The WNSSP and GCS scores were not associated. **Conclusion** The WNSSP is sensitive to behavioural change in slow-to-recover patients with severe traumatic brain injury. It demonstrates very high internal consistency reliability, and positive evidence of concurrent validity with FIM™ and the RLAS providing detailed description of cognitive-sensory behaviour within RLAS-levels.

## Keywords

Assessment, brain injury, cognition, domains of function, intervention, measurement, rehabilitation services

## Disciplines

Medicine and Health Sciences

## Publication Details

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# **Validating the Western Neuro Sensory Stimulation Profile for patients with severe traumatic brain injury who are slow-to-recover**

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## **Introduction**

Occupational therapists are significant contributors to neuro-rehabilitation, often working in multidisciplinary teams in acute, long-term and community settings. People with severe traumatic brain injury (TBI) need careful observation and assessment to inform clinical decision-making regarding care, treatment, discharge arrangements and evidence-based conversations with families regarding recovery. Although rehabilitation of people with brain injury has had significant attention in occupational therapy literature, very little has addressed the assessment of disorders of consciousness (DOC) in severe brain injury. This paper examines one measure used by occupational therapists in Australia that was developed specifically for survivors of severe TBI who are slow-to-recover, providing further evidence of validity.

Behavioural signs such as tracking objects with the eyes, responding to verbal instruction, or contingent behaviour such as smiling appropriately in response to emotional stimuli, are indicators of neural function known as “consciousness”. DOC are common following severe TBI. A DOC diagnosis is made when a person’s eyes are open, they are not in coma, but responses to the environment are minimal, inconsistent and/or inappropriate (Jennett & Plum, 1972; Jennett, 2005). Severe TBI survivors require 24 hour physical care, may have sleep/wake cycles, and display either no or “generalised, non-purposeful responses to stimuli ... [or] differentiated responses that are often delayed, inconsistent or selective” (Ansell, 1991, p.1017). They cannot attend, engage in purposeful, voluntary action or reliably communicate. A diagnosis of one of a number of DOC syndromes is made depending on the survivor’s pattern of recovery or deterioration: *coma*, where there are no sleep-wake cycles and the person cannot be aroused; *vegetative state (VS)* or *persistent vegetative state (PVS)* (Jennett, 2005) where there may be intermittent sleep wake cycles but no evidence of self awareness or purposeful engagement with the environment; and *minimally conscious state (MCS)* (Giacino et al., 2002), where there is occasional evidence of purposeful engagement but it is minimal. More recently, the term unresponsive wakefulness syndrome (UWS) has been developed and recommended by the European Task Force on Disorders of Consciousness (Laureys et al., 2010), but it is not yet in common usage. VS and MCS both indicate severe disorders of consciousness, but they have differential diagnostic criteria and in the case of MCS different levels of severity. For example, VS cannot follow commands; but in -MCS there is visual pursuit of objects to +MCS following commands (Giacino & Kalmar, 1997). When VS or MCS occurs over months or years, where little change is

apparent or where change is incremental and very small, these severe TBI survivors are considered slow-to-recover (Ansell, 1991, 1993).

Diagnosis of DOC has traditionally been made through ‘bedside’ expert judgement based on unstructured observation (Giacino & Schiff, 2009; Owen, Schiff, & Laureys, 2009) – but there is increasing evidence that diagnosis using standardised behavioural assessments is more reliable (Schnakers et al., 2009). When a patient is in bed most or all of the time, when behavioural change is very small, occurring over long time periods, and the behaviour is inconsistent, the chance of someone noticing incremental progress is low. Standardized ‘bedside’ behavioural assessments thus provide a mechanism to plot both stability and change across time-points, assessors and environmental stimuli (Giacino et al., 2009). Standardized behavioural assessments aim to elicit behaviours indicative of neuronal recovery (Giacino, et al., 2002). In doing so, they help clinicians distinguish between different DOCs (Bruno, Vanhaudenhuyse, Thibaut, Moonen, & Laureys., 2011). Multidisciplinary allied health teams commonly administer these standardised assessments as part of standard practice, providing evidence to inform decisions regarding prognosis, rehabilitation, personal care and living arrangements.

There are a large number of DOC behavioural assessments to choose from but few have been specifically developed for severe TBI patients who are slow-to-recover, even though the need for structured observation is clear because their behavioural change is minor and painstakingly slow. Assessments for these patients need test items requiring only small performance increments to demonstrate change. One such assessment which aims to elicit behaviours showing sequential change in cognitive-sensory function following severe TBI is the Western Neuro-Sensory

Stimulation Profile (WNSSP) (Ansell & Keenan, 1989; Ansell, Keenan & de la Rocha, 1989). It was developed when limitations were observed in another commonly used DOC measure, the Rancho Los Amigos Scale of cognitive function (RLAS) (Hagen, Malkmus & Durham, 1972), was used with severe TBI patients who were slow-to-recover. Ansell and Keenan (1991) identified that the RLAS did not show small incremental changes that could be observed in slow-to-recover patients “within” RLAS levels 2 and 3. WNSSP items identified cognitive-sensory domains where changes in behaviour represented the developmental and sequential change indicative of neuronal recovery (Smith, Taylor, Lammi & Tate, 2002). Twenty five years later, the WNSSP continues to be used in research and practice with slow-to-recover severe TBI survivors. Although there are now more DOC assessments available and some can be used with a broad range of DOCs including those at the VS and MCS end of the spectrum (such as the Coma Recovery Scale – Revised (CRS-R), Giacino, Kalmar, Whyte, 2004; Kalmar & Giacino, 2005), the lack of psychometric examination of these assessments in relation to severe TBI survivors who are slow-to-recover has meant the WNSSP has continuing relevance in clinical and research work.

The continued utility of the WNSSP has been confirmed in a recent systematic review of DOC assessments (Seel et al, 2010). This review examined psychometric properties of assessments and made recommendations regarding their use. Recommendations were graded according to how “reserved” authors were about assessment use. The degree of “reservation” was based on the relative strengths and weaknesses of test validity and reliability. The only DOC assessment recommended with “minor” reservations was the CRS-R (Giacino, Kalmar, & Whyte, 2004; Kalmar & Giacino, 2005) because of limitations in criterion validity

evidence. The next tier of recommendations included the WNSSP with “moderate reservations”. The test and psychometric information of the WNSSP is now described.

The WNSSP has thirty-three items constituting nine cognitive-sensory function subscales: arousal attention (4-items), auditory response (2-items), auditory comprehension (6-items), expressive communication (3-items), visual tracking (7-items), visual comprehension (5-items), tactile response (2-items), object manipulation (3-items), and olfactory response (1-item). Scoring is based on type of stimulation (general or specific), latency of reaction, and need for cueing. The total score range is 0 to 113; low scores indicate poorer function.

WNSSP total score range has been proposed by test developers to correspond with Levels 2 to 5 of the Rancho Los Amigos Scale (RLAS) (Hagen, Malkmus & Durham, 1972). The RLAS describes “behaviours seen at each stage of recovery [and] ...the WNSSP provides the clinician with more specific information on how each cognitive-sensory modality is functioning within the Rancho Scale levels” (Smith, Taylor, Lammi, & Tate, 2001, p.31). Level 5 on the RLAS is suggested to indicate readiness for rehabilitation (Hagen, Malkmus & Durham, 1972), because behavioural responses will be consistent and within reasonable time even though they may not be appropriate. In a study examining indicators of rehabilitation readiness (RR) in slow-to-recover patients, Ansell (1993), proposed the score of 72 on the WNSSP as a suitable cut-off because above 72 patients could demonstrate consistent responses to stimuli. She did, however, suggest that a single score could not be absolute and anything from 65 to 75 “probably represents RR

performance” (Ansell, 1993, p.91). The threshold score of 65 has therefore been adopted in this study as indicative of “rehabilitation ready” status.

Validity studies by test developers found the WNSSP and RLAS correlation was strong ( $r=0.73$ ,  $p<.001$ , 95%CI,  $p=0.001$ ) as was the correlation with Sensory Modality Assessment and Rehabilitation Technique (SMART) (Gill-Thwaites, 1997) total scores ( $r=0.7$ ). More recently, the WNSSP was correlated with expert judgement regarding participation of subjects in video-taped communication, arousal and awareness behaviour (Patrick et al., 2009). Here the WNSSP total score was related to the participation communication score ( $p<.0001$ ), but not arousal or awareness subscale scores.

Seel et al.(2010) examined all available evidence regarding psychometric properties of the WNSSP and summarised it as having: acceptable standardized administration and scoring procedures; good content validity that can discriminate between VS and MCS using two of the criteria from the Aspen Neurobehavioral Conference Work Group (Giacino et al., 2002); very high total scale internal consistency reliability ( $\alpha=0.95$ ) and acceptable arousal/attention, auditory comprehension and visual response subscale internal consistency ( $\alpha$  0.73-0.87) with poor internal consistency for other subscales ( $\alpha$  0.35-0.59). Seel et al. (2010) do not comment on concurrent validity, although they state that “criterion validity [is] unproven” as is inter-rater reliability, test-retest reliability and predictive validity (Seel et al, 2010, p.1805). It is these gaps in psychometric evidence that lead to recommendations for use with “moderate reservations”.

In addition to Seel et al.’s appraisal which included the full spectrum of DOC severity, the WNSSP has been criticised as not being sensitive enough to



detect change in very low functioning neurological patients (Pape, Heinemann, Kelly, Hurder, & Lundgren 2005); even though test developers found it useful in differentiating those who were rehabilitation ready from those who were not (Ansell, 1993). The behavioural sequence of recovery proposed through WNSSP item-order has also been challenged (Lannin, Cusick, McLachlan & Allaous, 2013). Further, there has been no examination of concurrent validity with measures of function - for example the Functional Independence Measure™ (FIM™) (Hamilton, Granger, Sherwin, Zielezny, & Tashman, 1987). Functional measures provide important data for service planning and provision, as it is these measures that provide information regarding the extent of dependency and care required, so understanding the association, if any of WNSSP scores and function would be of value.

The aim of this study was to investigate the validity of the WNSSP for patients diagnosed with severe TBI who were slow-to-recover. Specifically, the study answered the following questions:-

- (a) Could the WNSSP detect behavioural change from admission to discharge?
- (b) What is the internal consistency reliability of the WNSSP?
- (c) What is the concurrent validity of the WNSSP with the RLAS, the GCS and the FIM™?

## **Method**

A retrospective single site clinical cohort design was used, following precedent studies that also used medical record audits to retrospectively monitor recovery following TBI using the WNSSP (Smith, Taylor, Lammi, & Tate, 2001; Lammi,

Smith, Tate, & Taylor, 2005). The Smith et al. (2001) study used the WNSSP to describe cognitive-sensory recovery in people who were in MCS (n=25). The Lammi, Smith, Tate, & Taylor, (2005) study described long term outcomes (n=18; 2-5 years) for people in MCS. The study site was one specialist inpatient neurology rehabilitation centre in Australia. Human Research Ethics Committee approvals at the study site (Royal Ryde Rehabilitation Centre, NSW, Australia) and researcher institutions were obtained prior to data collection. All data was de-identified by an occupational therapist prior to analysis.

*Sample:* Archived inpatient rehabilitation medical records of all admissions from January 2001 to December 2006 were manually searched for patients who suffered a severe TBI. This was operationally defined as having a Glasgow Coma Scale (GCS) score <8 (Teasdale & Jennett, 1974) and duration of Post Traumatic Amnesia (PTA) greater than 1 week measured using the Westmead PTA Scale (Marosszeky, Ryan, Shores, Batchelor, & Marosszeky, 1997). Archived data was used to ensure (a) the total patient population of severe TBI admissions in VS or MCS was accessed, (b) a discharge had already occurred with a final WNSSP score in the record, and (c) none of the sample were current patients of the centre.

Thirty seven patients with severe TBI were identified. Medical records were inspected to include only those with a diagnosis of VS or MCS (i.e., who were slow to recover) which was all 37 patients. Medical records were inspected again to include only those with admission and follow up WNSSP scores. Four patients did not have both WNSSP administered and from the medical chart this appeared to be for no reason other than oversight. The final sample was n=33. Demographic details of the excluded patients are reported below.

*Instruments:* Demographic and clinical information was entered by an occupational therapist into an author designed data extraction form. Four standardised instruments were routinely reported in the medical record: the GCS; the WNSSP (version was the form published in the assessment manual by Ansell, Keenan & de la Rocha, 1989); the original version of the Ranchos Los Amigos Scale of cognitive function (RLAS) (Hagen, Malkmus & Durham, 1972); and the FIM™. The FIM™ 18 item 7-point scale Total, Motor and Cognitive Sub-scale scores were used (Hamilton, Granger, Sherwin, Zielezny, & Tashman, 1987).

*Data collection:* Doctors made the admission VS/MCS diagnosis; the record did not indicate how this was made. Upon admission to the centre, multidisciplinary teams administered the WNSSP, FIM™, RLAS and, if the patient was in coma, a post-admission GCS was also administered until the patient emerged from coma. Multidisciplinary teams included speech pathologists, occupational therapists and physiotherapists specialised in brain injury rehabilitation. Final measures were the last scores taken prior to discharge, hence they are reported as “discharge” scores below. All therapists working at the site were trained to use the GCS, WNSSP, FIM™ and RLAS by (a) reading, (b) observation of administration and scoring, (c) supervised administration and scoring with feedback. Data was collected in the same clinical setting during business hours using methods consistent with test guidelines. All clinicians undertaking the FIM™ assessments were trained in the use of the tool and had completed the credentialing exam

If the GCS at-scene score was reported in the medical record this was used (n=31 patients had at-scene scores), otherwise the CGS admission score was used to establish severity of coma for study inclusion (N=2). The WNSSP, FIM™ and

RLAS measures were routinely administered from day of admission even when coma was evident. FIM total and subscale scores were extracted for this study but not individual item data. Because WNSSP test authors (Ansell, 1993) claim a minimum total score of 65 is the threshold for rehabilitation ready status, we recorded whether or not patients scored over 65 and if they were then referred to continuing rehabilitation on discharge. It was later found that centre practice was to routinely refer patients for follow-up therapy regardless of discharge destination or recovery level, and in this study it occurred for 81.8% (n=27). Therapy referral and discharge destination were therefore reported as demographic data but discarded from inferential analysis. An earlier study examining the sequence of recovery (Lannin, Cusick, McLachlan, & Allaous., 2013) was conducted using the same data set, with demographic, clinical and outcome data including total and subscale WNSSP scores reported. The present study used a slightly different sample from the data set because only admission and discharge scores on the WNSSP were required for inclusion; for this reason results may differ from the Lannin, Cusick, McLachlan, & Allaous. (2013) study.

*Data analysis:* Demographic and clinical data was analysed using descriptive statistics. Relationships between the WNSSP, GCS and RLAS were tested using Spearman's *rho* (two-tailed). Correlation coefficients between WNSSP total admission and FIM<sup>TM</sup> discharge scores Spearman's *rho* (two-tailed) were examined. Strength was determined as follows: correlation coefficients (in absolute value)  $\leq 0.35$  were considered to represent weak correlations; 0.36 to 0.67 were modest; 0.68 to 0.90 were strong; and coefficients  $> 0.90$  were very high correlations (Mason, Lind, & Marchal, 1983; Weber & Lamb, 1970). Cronbach's

alpha was used to examine internal consistency, with alpha  $>.7$  deemed acceptable (Arrindell & van der Ende, 1985).

## **Results**

All 33 eligible participants had severe brain injury (GCS at-scene mean score of 3.87; median 3; range 3; SD 1.1; the 2 patients without at-scene CGS scores recorded had admission CGS scores below 8). All patients were diagnosed in VS or MCS on admission, with most having extended periods prior to admission being cared for either in an acute hospital or in 24-hour care centres such as a nursing-home following their injury. They were predominantly injured in motor vehicle accidents (67%,  $n=22$ ). The four excluded patients all had severe brain injury (GCS at scene 4, 3, 6 and 6); three were injured in road or traffic accidents and one by a collapsed wall.

*Clinical and demographic characteristics of sample:* Table 1 presents sample characteristics. 82% were male ( $n=27$ ); mean age of 28.2 (SD 12.0; median age 25 years); at time of admission to the specialist centre a mean of 77.6 days post-injury; length of coma was a mean 134.8 days (median 104 days; SD 101; 6 missing; range 357); length of PTA (days) at time of admission could only be calculated with confidence for  $n=8$  patients due to missing data. For them, PTA on admission was a mean 128 days (median 124; SD 63.6, range 180). The remaining  $n=25$  met inclusion criteria because PTA was evident for more than one week after admission). 76% had not emerged from PTA by study completion ( $n=25$ ). All but two patients had emerged from coma by study end. The four excluded patients were all male, had a mean age of 35.5 years; and an estimated mean of 70 days post injury at study commencement; length of coma was 94 days for one patient – the other 3 had missing data; length of PTA on admission for two excluded patients was 57 and 74 days respectively with 2 cases missing; 2 had not emerged from PTA by the end of the

study. Admission and discharge RLAS and FIM™ scores are presented in Table 2. Most scored RLAS 2 or 3 on admission, indicating severe TBI. Twelve participants (36%) obtained a RLAS 5 at discharge. The majority scored the FIM™ “floor” of 18 at admission (n=28, 87%), and a third did so again at discharge (n=13, 41.9%).

*WNSSP ability to detect change:* Table 2 presents WNSSP total scores showing a large distribution at both time points and a difference in median scores of 44 (median improvement of 39%) and mean scores of 31.9 (mean improvement of 28%) from admission to discharge. On admission the majority of participants (85%, n=28) had total WNSSP scores below 65 (the minimum score suggested by Ansell in 1993 to indicate rehabilitation readiness). More than half exceeded this range by discharge (n=22, 67%).

*Internal Consistency Reliability:* The WNSSP total scale reliability coefficient ( $\alpha=.933$ ) was significant at  $p<.01$  level (two tailed). Accurate reliability coefficients for subscales could not be obtained due to missing data and limited items in two of the subscales.

*Concurrent validity of the WNSSP and FIM™ at admission and discharge:* There was a weak but significant relationship between WNSSP Total admission scores and FIM™ Total admission scores ( $r_s = -0.146$ ,  $p=0.0424$ ); no significant relationship between WNSSP Total admission scores and FIM™ Motor subscale admission scores ( $r_s = -0.140$ ,  $p=0.445$ ); and no significant relationship between WNSSP Total admission scores and FIM™ Cognitive subscale admission scores ( $r_s = -0.207$ ,  $p=0.255$ ). Correlation between WNSSP Total discharge and FIM™ Total discharge scores was not significant ( $r_s = 0.382$ ,  $p= 0.41$ , two-tailed), but there was a modest, significant correlation for both FIM™ Motor subscale discharge scores ( $r_s = 0.374$ ;  $p=0.045$ ), and FIM™ cognition discharge scores ( $r_s = 0.412$ ;  $p=0.026$ ).

*Concurrent Validity of the WNSSP and GCS:* There was no significant relationship between WNSSP total admission scores and GCS at-scene ( $r_s = .137$ ,  $p=0.461$ ). There was insufficient data to examine discharge GCS scores or admission GCS scores.

*Concurrent Validity of the WNSSP and RLAS at admission and discharge:* There was a strong significant correlation between admission WNSSP Total and RLAS admission scores ( $r_s = .693$ ,  $p=0.01$ , two-tailed). Correlation between WNSSP Total and RLAS discharge scores was also strong ( $r_s = .788$ ,  $p= 0.01$ , two-tailed).

## **Conclusion**

DOC may arise following severe TBI. Accurate, reliable assessment of altered states of consciousness following injury and during recovery is needed to inform the family about progress and help clinicians to make evidence-based treatment and discharge planning decisions. One standardised DOC assessment developed specifically for patients with severe brain injury, who are slow-to-recover, is the WNSSP. The present study contributes validity information regarding use of the WNSSP with this clinical population.

*Demographic and clinical characteristics of the study sample:* This study used a homogenous sample of patients who had sustained a severe TBI and were slow-to-recover. All severe TBI patients admitted to the specialist multidisciplinary rehabilitation centre during the six year data collection period were slow-to-recover ( $n=37$  in total, of whom 33 had records that enabled inclusion in this study sample). Severe TBI does not always result in slow-to-recover outcomes, so this needs some explanation. It may be due to the fact this was a specialist in-patient rehabilitation hospital receiving referrals from other services. Some of these patients, had, for

example, spent long periods in acute hospitals being medically stabilised or they had stayed in nursing homes since their original injury.

Most participants were men, injured in motor vehicle accidents, emerging from coma but remaining in PTA at study conclusion. The sample demonstrated poor function at the beginning and end of the study, with FIM™ performance typically at the lowest level at admission, and a third remaining there at end-of study. All participants required 24 hour supported care at discharge. Those who improved did so by a median of 10 FIM™ points. The low level of function at beginning of study was mirrored by low scores on the RLAS with most on 2 or 3, but by the end of the study most had improved (median score of 4), but only a third reached the “rehabilitation ready” level of 5 on the RLAS.

*WNSSP sensitivity:* This study had very low functioning patients and WNSSP admission scores reflected this, with 85% having scores below the rehabilitation ready threshold score of 65. Over the course of the study, most (67%) exceeded 65 by discharge and overall the median WNSSP score more than doubled from admission to discharge. Like Smith et al. (2001), we found the range within and change between WNSSP scores at admission and discharge demonstrated sensitivity in describing sensory cognitive function “within” RLAS levels. At discharge for example, only a third of patients were identified as “rehabilitation ready” by the RLAS (level 5), whereas the WNSSP scores showed that 67% were rehabilitation ready using the minimum threshold score of 65. While this is in part because the range of WNSSP scores associated with RLAS levels overlaps (Smith, Taylor, Lammi, & Tate, 2001), it also demonstrates that the WNSSP provides more detailed description of performance levels in cognitive sensory domains proposed to



be associated with rehabilitation readiness. The criticism by Pape, Heinemann, Kelly, Hurder, & Lundgren (2005), that the WNSSP lacks sensitivity for low functioning neurological patients therefore does not appear to be supported by this study.

*Internal consistency:* This study confirms previous findings that the WNSSP internal consistency was very high. The WNSSP is a strong measure of a construct, which WNSSP authors have called “neuro-sensory cognitive function”. Therapists can have confidence when using this assessment that it is targeting a defined domain of performance postulated to represent neural recovery.

*Concurrent Validity:* The study confirms previous findings that the RLAS and WNSSP measure similar constructs as their correlation at admission and discharge was strong in slow-to-recover patients with severe TBI. The WNSSP has more intervals than the RLAS and so is able to present change “within” RLAS levels. This may be helpful in monitoring progress of slow-to-recover patients and providing information to families about what behaviours may be non-purposeful or reflexive and what may be intentional behaviours that show small incremental change over long periods of time.

The study found a weak association between admission FIM™ Total and WNSSP Total scores; and modest discharge WNSSP and FIM™ Motor and Cognitive subscale associations. These findings suggest that the WNSSP and FIM™ may measure some aspects of recovery that are similar although it is not as straightforward or strong as the RLAS correlation. A global measure of function like the FIM™ is probably not as useful in monitoring clinical progress in slow-to-recover patients compared to the RLAS or WNSSP. The FIM™ is, however, an

important measure to capture levels of care required, for slow-to-recover patients who need 24-hour supported care.

This study confirms that the GCS and WNSSP measure different constructs because there was no association between admission WNSSP and at-scene GCS. We did not expect one because the GCS proposes to measure coma (behavioural evidence that consciousness is not present) while the WNSSP measures behaviour when consciousness of some sort has returned. At-scene and WNSSP scores were also separated by medical recovery time. The finding that the GCS and WNSSP measure different constructs confirms the utility of concurrently administering the GCS and the WNSSP until such time as it is clear the patient is not in coma. This practice can also provide useful information to families about different consciousness states and what clinicians are looking for to determine change from unconscious to conscious states.

*Limitations:* The study sample was modest at  $n=33$ . This sample size was ‘middle of the range’ when compared with other WNSSP studies specifically focussed on severe TBI, (e.g., Ansell & Keenan, 1989,  $n=57$ ; Gill-Thwaites & Munday, 2004,  $n=60$ ; Lammi, Smith, Tate & Taylor, 2005,  $n=18$ ; Patrick et al, 2009,  $n=10$ ; Smith, Taylor, Lammi, & Tate, 2001,  $n=25$ ). Data was extracted from medical records that were prepared for clinical, not research purposes consequently missing data was a problem. Data quality can be assumed to be good because assessment-trained specialist neurology therapists administered measures and neuro-rehabilitation staff made the diagnoses. But there was potential for variability in data quality, including the possibility that admission and discharge assessments were made by the same therapist. The other limitations in the study are that we did

not collect individual item performance on the FIM™, we did not differentiate between VS or MCS at admission, and we did not track changes in DOC diagnosis during the study period. This meant WNSSP score ranges for each diagnosis could not be analysed.

Overall, this study provides further evidence to support continued use of the WNSSP with severe TBI survivors who are slow-to-recover. It is sensitive to change and provides detailed description of sensory-cognitive domains of behaviour through item and subscale performance. This study found very high internal consistency, strong concurrent validity with the RLAS, weak admission and modest discharge concurrent validity with the FIM™. The WNSSP can provide useful information to clinicians regarding change in slow-to-recover patients that may help inform their clinical decisions and discussions with families. Further research is required in relation to inter-rater, intra-rater and test-retest reliability, criterion and predictive validity.

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**Table 1: Participant Characteristics**

<b>Variables</b>	<b>N</b>	<b>%</b>	<b>SD</b>	<b>Mean</b>	<b>Median</b>
Age in years	33	100	12	28	25
Male	27	82%			
Female	6	18%			
English is primary language	30	91%			
Cause of injury (n=1 missing):					
Road or Traffic Accident	22	67%			
Fall	2	6%			
Assault	2	6%			
Bicycle Accident	1	3%			
Horse Riding Accident	2	6%			
Hit by train	1	3%			
Parachuting Accident/Fall from height	1	3%			
Skateboarding Accident	1	3%			
Type of brain injury:					
Open	3	9%			
Closed	19	58%			
Closed with neurosurgery	11	33%			
Glasgow Coma Scale at scene	31	94%	1.1	3.9	3.0
Length of coma (in days)	27	82%	101	135	104
Did not emerge from coma before end of study	2	6%			
Length of time in study (in days) Range: 2 - 370	29	88%	98.51	80.98	41.97

Discharge destination					
Home	11	33%			
Transitional living facility	2	6%			
Nursing home	13	39%			
Acute hospital	4	12%			
Rehabilitation facility	1	3%			
Missing	2	6%			
Advance to active rehabilitation	27	82%			



Table 2: Admission and Discharge Scores

<b>Outcome Measure</b>	<b>Admission</b> Median (Mean, Range, Standard Deviation)	<b>Discharge</b> Median (Mean, Range, Standard Deviation)
WNSSP <sup>†</sup> Total score (n=33, 100%)	32 (38.3; range 108; SD 29.6)	76 (70.2; range 110; SD 31.6)
FIM <sup>TM‡</sup> Total (n=32, 97%)	18 (18.7; range 12; SD 2.4)	28 (44.5; range 105; SD 39)
FIM <sup>TM</sup> Motor Subscale	13 (13.4; range 5; SD 1.4)	16 (32.3; range 78; SD = 31.1)
FIM <sup>TM</sup> Cognitive subscale	5 (5.2; range 7; SD = 1.2)	10 (12.2; range 27; SD 8.9)
RLAS <sup>§</sup> (n=32, 97%)	1 (2.7; range 3; SD 1.0)	4 (4; range 3; SD=1.0).

<sup>†</sup> Western Nero-Sensory Stimulation Profile

<sup>‡</sup> Functional Independence Measure<sup>TM</sup>

<sup>§</sup> Ranchos Los Amigos Scale of Cognitive Function